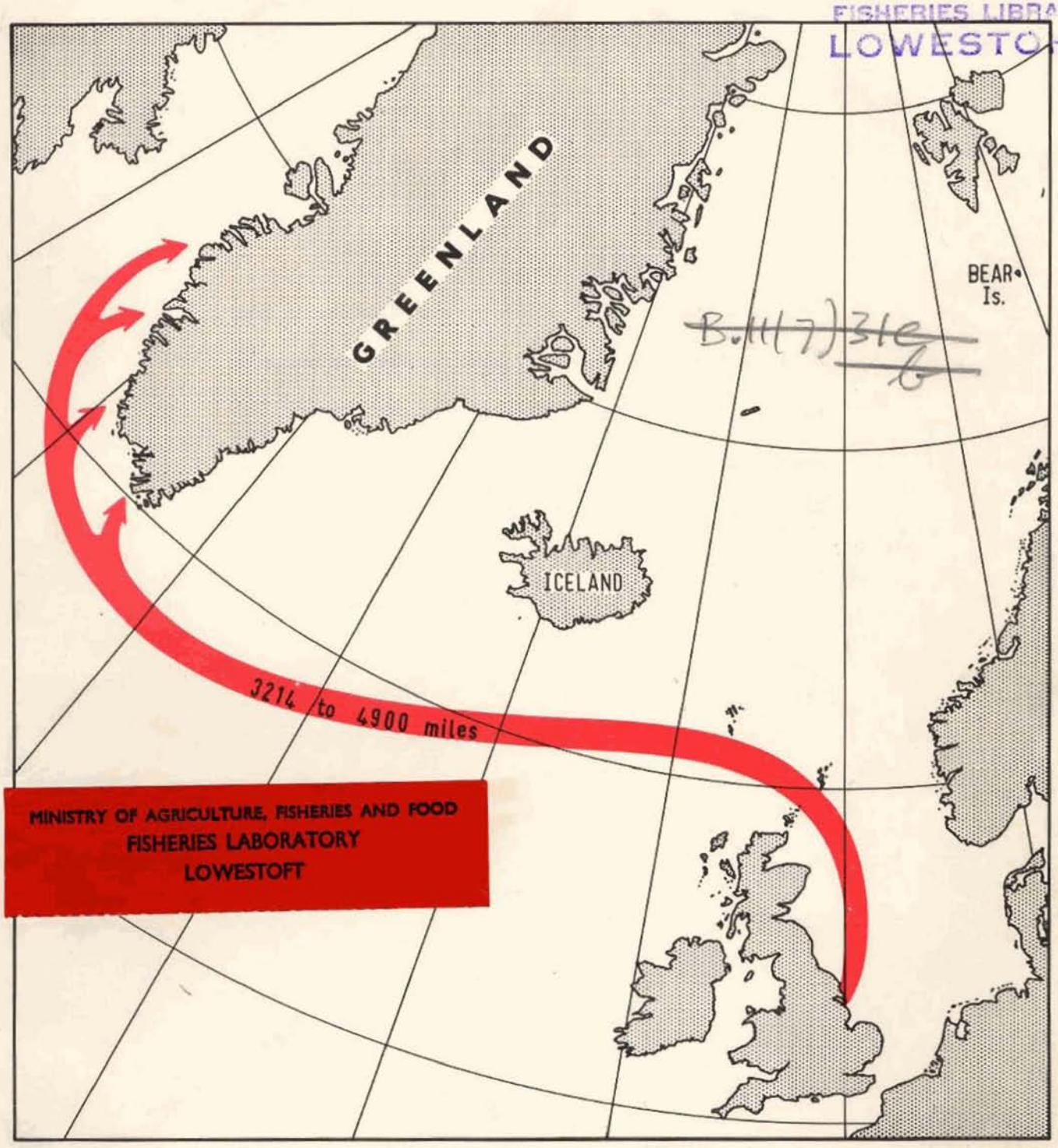
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

THE WEST GREENLAND COD FISHERY



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Introduction

Everyone with an interest in the English distant-water fisheries knows that in the summer of 1963 a considerable amount of fishing activity was diverted from the north-east Arctic grounds in the Barents Sea and at Bear Island to the West Greenland Banks. The reason for the switch is equally well known; catch rates in the north-east Arctic had fallen to such an extent that the West Greenland grounds became a more profitable enterprise despite the extra steaming time and additional hazards involved. The extent of this fall-off in production in the north-east Arctic can be judged from the results of Hull trawlers fishing the Barents Sea, where they averaged 96 kits per day between May and July 1963 compared with 128 kits per day in the same period of 1962. The reasons behind this sudden drop have been made the subject of a separate investigation; the purpose of this leaflet is to outline our present knowledge of the Greenland stocks, because it is apparent that our distant-water fleet will rely more heavily upon this and adjacent stocks in the north-west Atlantic in the years to come.

Hitherto English trawlers have fished Greenland only during the late autumn and winter when the traditional grounds in the north-east Arctic and at Iceland have passed their seasonal peak of production; so the move to fish at Greenland during the summer months marks a fundamental change. However, ours is not the only fleet to have felt the effects of declining catch rates in the north-east Atlantic generally, and other countries are also looking to the north-west Atlantic for their fish. Consequently it is worth while to review the present picture of total international fishing activity throughout the north-west Atlantic, so that the English contribution can be placed in proper perspective.

Total international catches of cod in the north-west Atlantic and at Greenland

The total international catch of cod for the years 1952-1963 is given in Table 1, where it is broken down by area of origin (Table 1A) and also by the nations participating in the fisheries (Table 1B). Looking first at the overall total for the north-west Atlantic in Table 1B, after the catch of 1,000,000 tons in 1952, the catches were fairly steady around 900,000 tons until 1960. Then, in 1960 and 1961 they increased sharply to their present level of just over 1,300,000 tons. This expansion has taken place at Greenland and Labrador whilst catches at Newfoundland have remained steady. The Newfoundland and Greenland stocks now produce 65 per cent of the cod caught in the north-west Atlantic.

Table 1 The total international catch of cod from the north-west Atlantic (in thousands of tons round fresh fish)

A. Shown by the area of origin

Year	West Greenland	Labrador	Newfoundland	Nova Scotia	New England	Unknown
1952	294	61	328	132	14	188
1953	242	128	352	159	11	13
1954	302	22	472	149	12	12
1955	265	26	429	159	12	10
1956	321	34	390	198	13	9
1957	269	32	449	188	13	7
1958	320	40	294	214	16	-
1959	234	60	425	213	16	5
1960	243	188	471	218	14	-
1961	345	265	461	212	18	3
1962	451	255	389	219	26	-
1963	406	216	466	212	30	-

B. Shown as the catch by each participating country

Year	Canada (Maritimes)	Newfoundland	(Faroes / (Greenland		France	Germany	Iceland	Italy	Norway	Poland	Portugal	Spain	U.S.S.R.	U.K.	U.S.A.	Total
1952	131	219	68		171	2	64	11	28	-	161	82	-	59	19	1,017
1953	101	189	28	23	141	3	18	13	39	-	196	98	-	34	15	906
1954	109	246	31	19	156	2	3	12	49	-	195	112	-	19	16	969
1955	108	208	36	20	140	7	9	10	43	-	205	96	-	6	15	902
1956	133	220	32	21	114	29	9	9	42	-	225	110	3	3	15	966
1957	131	222	36	25	122	11	10	7	36	-	205	110	18	12	15	958
1958	123	165	47	26	122	31	10	3	43	-	179	100	6	11	18	884
1959	124	232	46	28	131	21	3	5	31	-	159	124	15	16	18	953
1960	108	228	60	27	145	37	6	2	36	-	185	158	103	22	16	1,134
1961	103	183	62	34	172	99	11	3	46	1	197	197	158	18	19	1,304
1962	115	206	97	35	160	126	1	1	34	4	218	197	101	25	20	1,340
1963	106	222	92	31	118	121	4	-	22	8	231	209	82	40	19	1,336

Table 2 International catches of cod at West Greenland, shown by country and by sub-area (in thousands of tons round fresh fish)

Year	(Faroes	(Greenland	France	Germany	Iceland	Norway	Portugal	Spain	U.S.S.R.	United Kingdom	Total	Sub area A-D	Sub area E-F	Unknown
1954	50		64	1	3	49	113	2	-	18	302	223	21	58
1955	36	20	34	7	9	43	104	7	-	5	265	184	15	66
1956	32	21	30	29	9	41	126	32	-	2	321	236	21	64
1957	33	25	27	11	10	20	112	23	-	10	269	168	55	46
1958	44	26	24	30	10	36	113	27	-	9	319	186	59	75
1959	38	28	30	17	+	27	67	14	-	12	234	134	34	66
1960	51	27	21	24	5	32	66	4	-	12	241	131	39	72
1961	56	34	40	84	11	43	68	1	-	8	345	211	46	88
1962	93	35	53	125	1	32	92	3	-	16	451	275	60	116
1963	78	31	36	118	4	19	63	+	5	27	382	223	62	97

Of the participating countries Newfoundland itself catches the largest single share, but Portugal, France and Spain have always taken a major part. The recent increase has gone mainly to fishermen from Faroes, Portugal, Spain, the U.S.S.R. and particularly Germany. In 1963 English vessels took only 3 per cent of the total.

In Table 2 catches at West Greenland only are broken down by country and by sub-area for the ten years since 1954. Until 1960 the total catches were fairly steady at 250-300 thousand tons a year, with Portugal, France and Norway taking the major part. However in the last four years the activity of all European fishing nations has increased, including Iceland and Faroes, giving a total catch of around 400 thousand tons in 1962 and 1963. In particular, fishing effort by German trawlers has trebled, although this has been partially offset by the diversion of some Portuguese and Spanish trawlers to other grounds, e.g. Labrador. At the present time trawlers from at least ten different countries take part in the fishery, in addition to the line fisheries of Greenland itself, Norway and Portugal. Russian catches of cod recorded from Greenland are at present very low because silver hake rather than cod is now the main objective of their fishery in the north-west Atlantic, but, on the other hand, vessels from still other nations, e.g. Poland and Japan, are beginning to participate. The switch of English effort to Greenland in 1963 increased our share of the total from 3 to 7 per cent, so that our contribution is still very small, yet from this one can judge the intensity of fishing in the area. It is pertinent to ask whether the stocks can maintain their recent attractive catching rates in the face of this build-up in effort. The effects of similar increases on north-east Atlantic stocks are all too familiar, and the possibility of history repeating itself must be borne in mind.

Before discussing this critical issue it is necessary to look first at the water temperatures around Greenland and at the biology of the cod stock in the area, because it has not always been able to support a trawl fishery and, if the biological basis of the resource is unstable, anything could happen, irrespective of the build-up in fishing activity.

Water conditions at Greenland

The major fishable stocks of cod in all parts of the north Atlantic occur in areas where water of around 2°C covers the sea bed at depths of less than 300 fathoms. On the Greenland banks this temperature is maintained by the interaction of two oceanic currents, one a very cold current travelling south down the coast of East Greenland from the Polar Sea, and the other a warm offshoot of the

Gulf Stream, the Irminger Current, which flows south-westward from Iceland. These two currents meet off East Greenland and turn at Cape Farewell to flow northward over the shallow banks off West Greenland (see Figure 1). The water in the Polar Current is itself far too cold for cod and they owe their existence at Greenland to the warming influence of the Irminger Current. This interaction of cold and warm currents is common in the Arctic; but at Greenland, because the shallow banks are narrow in width, it means that small changes in the strength of either current can have a marked effect on the area suitable for cod. This situation also occurs off Spitzbergen. One of the reasons for the patchiness of cod fishing in both areas is, in fact, connected with the movements of warm and cold water. If the cold current intrudes along the sea bed below the warmer water of the Irminger Current, then the fish may lift off the sea bed and remain in mid-water until the local current system changes again.

In general warm years are likely to be more favourable for cod, the increased temperature enabling them to disperse over a wider area of the banks. This also means that the fish will not be so tightly concentrated, which is a disadvantage to the fishermen though the ice conditions may be less hazardous. A rough indication of the warming influence of the Irminger Current in particular years can be gained from the distance that drift ice travels up the west cost before it melts.

The physical conditions at Greenland thus seem to be more delicately balanced than in most of our cod fisheries, and in fact fishable concentrations have not always been present off Greenland. Cod were fished here around 1840–1850 but thereafter they became extremely sparse until about 1916. This change can be related to the trends in surface temperature, which are shown in Figure 2 for the years since 1878. The changes are expressed as deviations from an average based on the years 1876-1915. This information, which is taken from the work of Danish scientists, shows that temperatures were falling at the beginning of the period, and from this, and other records of ice conditions, it seems probable that temperatures were above the average at the time of the 1840 fishery. This was followed by a cold period (1870–1917) coinciding with the reduced numbers of cod but, in 1920, a sudden rise in temperature was soon followed by a revival of the cod stock, as indicated by a dramatic expansion of the Greenlanders' line fishery. Other nations began trawling in the 1920s and the fishery has continued ever since, though it is apparent that sudden changes can happen in this area.

The origin of Greenland cod

Since cod were virtually non-existent at Greenland at the turn of

century, where did the fish come from that reappeared off South Greenland in 1917? It is certain that there were always a few cod in the area, even during the cold period, and it may be that the warming of the water led to a series of highly successful year-classes. The 1917 and 1922 year-classes were relatively good, yet the Greenlanders' line fishery had improved before these groups of fish were large enough to contribute to the fishery. Tagging experiments carried out by Danish scientists in subsequent years showed that these Greenland cod had some connection with Iceland. It may be that some of the cod which repopulated Greenland came from Iceland, possibly as spent cod drifting with the Irminger Current after spawning off south-west Iceland. This possibility is supported by the results of an international survey of the area in 1963, which, besides showing cod spawning off East Greenland itself, also showed some drifting of cod larvae from Iceland with the Irminger Current. It is doubtful if any cod could have reached Greenland from the Labrador or Newfoundland areas: the hydrographic charts show that the prevailing currents would prevent any cod, young or old, from drifting eastward.

The present cod stocks at Greenland

Shortly after the revival of the fishery in the 1920s the main part of the stock was to be found in the Julianhaab area off South Greenland. Tagging experiments on these cod, which were carried out in the 1930s, showed that as they matured many of the cod migrated to Iceland to spawn; in fact some 70 per cent of the recaptured tagged fish were taken on Icelandic grounds. At the same time spawning probably occurred on the banks of south-east Greenland, e.g. Fylkir Bank, and it now appears that this area has become the more important spawning area for cod at South Greenland; at least, recent tagging experiments have not shown such large-scale migration to Iceland, though some interchange still takes place.

Some of the baby cod spawned on the south-east banks were drifted around Cape Farewell and on to the West Greenland banks. Thus the entire area was gradually repopulated and spawning began to occur off West Greenland itself, especially on Fyllas Bank. From here the baby cod drifted even further north as far as Disko Bay.

There are now two main stocks at Greenland, one on the west coast occupying the banks north of Frederikshaab and spawning within the same area (sub-areas A-D) and the second, the 'original' Greenland stock, occupying the west coast south of Frederikshaab (sub-areas E and F), and extending along the east coast. These areas are shown in Figure 1.

Some other isolated fjord stocks are known to exist but these are not important to our trawlers.

The tagging experiments already referred to have shown very little interchange between these two main stocks. Very few of the fish tagged in the northern stock areas have been recaptured in the southern area or at Iceland, though there appears to be a tendency for the young cod, which have drifted north from the west coast spawning, to spread southward again as they grow older. Similarly few of the southern group move to West Greenland, though there is still some connection with Iceland.

These distinctions between the stocks mean that heavy fishing on the West Greenland banks will not necessarily have any effect on the numbers of cod in the southern stock, and vice versa. On the other hand heavy fishing south and east of Greenland may influence the number of cod spawning at Iceland, and in this there is some similarity to the situation in the north-east Arctic, where heavy fishing on young cod in the Barents Sea and at Bear Island has affected the number of spawning cod at the Lofoten Islands.

These then are the important cod stocks on which future catches at Greenland will depend. The actual catch rates in a particular year will be governed by two factors: the water conditions, which have already been discussed, and the number of cod in the stock. This number is itself controlled by the amount of fishing going on and by the success of spawning in particular years. Again, owing to the water conditions, this second factor is more than usually critical to the Greenland fishery and needs some further explanation.

The importance of successful spawning at Greenland

As all fishermen know, cod spawn once a year, in the spring. Thereafter, in each year of their life, the newly spawned cod lay down a ring on their ear stones, or otoliths. By using these rings to age the cod in the stock and combining this with the length measurements taken in market samples, it is possible to recognise how many of the fish were born in particular years, forming a part of that year-class. In 1962, for example, the catches were mainly cod spawned in 1955 (seven years old), 1956 (six years old) and 1957 (five years old). This is shown in Figure 1. In 1963 these age-classes were one year older; the 1955 class was eight years old and relatively less important; the 1956 class (seven years old) and the 1957 (six years old) were joined by a new group of five-year-olds, the 1958 class, to form the three most important year-classes in the fishery.

The number of young cod surviving in any one year-class varies from year to year in all fisheries, but at Greenland these fluctuations are particularly sharp. There may be a run of very moderate year-classes,

followed by one year in which survival is exceptionally good. This also shows up in Figure 1; in the northern stock the 1957 class was particularly strong, but in the south and east the catches depended more on the 1956 class. Where they occurred these two year-classes provided 50-60% of the catch; but before this only the 1953 and 1947 year-classes had been outstanding in the post-war years.

Over the years the strength of different year-classes of Greenland cod has been measured by Danish scientists and their most recent results show that survival is connected with water temperature. Figure 3, which is taken from their results, shows how the average temperature on Fyllas Bank in June provides a measure of the success of spawning two months previously. In warmer years survival of baby cod is much better. The illustration shows why the 1957 class in the northern stock was so much better than the 1956 class in this area - in 1957 the water was about 1°C warmer. This may not seem much, but it is considerable for cod living near the lower limit of survival.

The 1957 class was 5, 6 and 7 years old in the three years 1962-1964, and during these years it made its greatest contribution to the fishery. From 1964 onwards the fishery will be dependent on newer year-classes and of these the next two, those of 1958 and 1959, were spawned in cold years and consequently seem to be weaker in numbers than the 1957 class. These two rather poor year-classes are now in the stock as 5- and 6-year-olds - hence the poorer catch rates in late 1964. However, the 1960 and 1961 year-classes are much stronger and these should give improved numbers of small cod which will grow to a size of interest to trawlermen during 1965 and 1966. There have been individual reports of them in autumn of 1964 when they were still too small for market and had to be discarded at sea.

Judging from the year-class strength in the stock, the number of fish entering the Greenland fishery in 1965 should be quite high, but there still remains the most critical question of all - what will be the effect of fishing on these year-classes? This is important, because their average survival in the stock depends on the amount of fishing: with little fishing every fish has a good chance of growing to a 'ripe old age' but if fishing is very intense then they tend to be caught at very young ages and, more important, at correspondingly smaller sizes. Carried to a logical extreme, fishing could become so heavy that a year-class could be wiped out before the fish have grown much above a marketable size. Indeed this is a possible explanation for the present situation of the north-east Arctic cod fishery.

The short-term effect of fishing on Greenland cod

As fishing intensity goes up the chances of survival of individual

cod are reduced; so the average size of fish in the catch drops and with it there follows a decline in the catch rate. This pattern is well documented for the cod stocks in the north-east Arctic, at Iceland and at Faroes, and there is no reason to suppose that Greenland cod will react to fishing in a different way.

Figure 4 shows the pattern of events in the four north-east Atlantic cod stocks mentioned above for the post-war years. The catch rate is expressed as a proportion of the catch rate at the time when fishing was just beginning again after the war. The decline is indisputable, but in addition to showing the fall in catch rates the line also reflects the falling profitability of a fishery. The question to be answered is: whereabouts on this line do the present catch rates at Greenland lie and what changes can be expected in the near future?

To provide the answer we need measurements of catch rates and the amount of fishing for a long series of years, in order to see how they are changing. The records of English trawlers provide a measure for the southern stock and the records of Portuguese dory fishermen give measurements for the northern stock, but there is no way of combining the two sets of information. So far as it goes this information is shown in Figure 5; in both stocks the abundance of cod (as indicated by catch per unit effort) fell sharply around 1957 and 1958, but there has since been a slight recovery as the strong 1956 and 1957 year-classes have come into the fisheries. Fishing effort has been increasing steadily since the mid-1950s.

Other measurements have been taken from the results of trawling by continental countries and though these are generally less reliable than our own, they do refer to the entire stock. In Table 3A the catch per unit effort is given for otter trawlers from Faroes, Portugal, France, Germany, and Spain. In Table 3B the yearly changes for each country are expressed as a percentage relative to the catch rate in 1954 as 100 per cent. The average of these is taken as a measure of the change in catch rate and this, combined with the total catch, can be used to estimate the change in the amount of fishing. The sum indicates that since 1954 the fishing intensity has increased to two and a quarter times its former level and the catch rate has fallen by 40 per cent. This locates the 1962 rate of fishing at Greenland at 14.5 units of effort on Figure 4, with the stock standing at about 40 per cent of its original level. If the total international fishing effort were to increase by 20 per cent, to 17.5 units of effort, then the stock would decline to about 34 per cent of its original level, i.e. a drop of 15 per cent from the 1962/63 catch rate.

Table 3

A. The catch per unit effort of cod (tons round fish) by otter trawlers at West Greenland

Year	Catch per day on grounds		Catch per day fished		
	Faroes	Portugal	France	Germany	Spain
				(501-900t)	
1954	26.2	31.9	36.9	26.8	20.6
1955	29.0	37.6	37.1	-	25.9
1956	30.4	36.4	32.5	29.9	29.3
1957	25.2	27.3	27.4	18.2	17.4
1958	20.1	26.8	24.3	19.6	18.9
1959	14.0	14.5	21.0	19.1	12.7
1960	15.1	15.9	24.0	19.8	13.0
1961	14.6	12.7	28.4	13.0	16.5
1962	16.3	16.6	31.0	16.6	14.2

B. Percentage change in catch per effort, total catch and effort relative to 1954 as 100%

Year	Otter trawlers					Mean c.p.e.	Total Catch	Total Effort
	Faroes	Portugal	France	Germany	Spain			
1954	100	100	100	100	100	100	100	100
1955	111	118	101	-	126	114	88	77
1956	116	114	88	112	142	114	106	95
1957	96	85	74	68	84	81	89	110
1958	77	84	66	73	92	78	106	136
1959	53	45	57	71	62	57	77	135
1960	58	50	65	74	63	62	80	129
1961	56	40	77	48	80	60	114	190
1962	62	52	84	62	69	66	149	226

The immediate future of fishing at Greenland

This discussion has shown how the fishing prospects at Greenland depend on three factors:-

i) the water temperature,

ii) the year-class strength, and,

iii) the total amount of fishing by all countries.

The first of these factors is at present unpredictable: particularly favourable weather and ice conditions can result in good catch rates even when the abundance of the stock is poor, and though some years may be generally better or worse than others, many of the fluctuations in catches caused by water temperatures are of short duration and tend to average out over the whole year.

The year-class strength is not of special interest in predicting the immediate future at Greenland, because the year-classes upon which the fishery will depend up to 1970 have already been born. Of these we expect the 1960 and 1961 classes to be good but the 1962 and 1963 broods seem to be less numerous, though it is too early to be sure. Consequently, if the total international fishing effort remains at the present level, catch rates should improve again in 1965 as fish of the 1960 year-class grow to commercially valuable sizes. This group has already been fished in 1964, but the fish were then too small and were rejected at sea. If international fishing effort increases then the anticipated decline in catch rate that must follow will be temporarily offset by the good year-classes for perhaps two years. Thereafter some decline must be expected but the extent of the drop will depend very much on just how intense the fishing becomes. This we cannot forecast, but the decline to be associated with a given percentage increase in international fishing at Greenland can be judged from Figure 4.

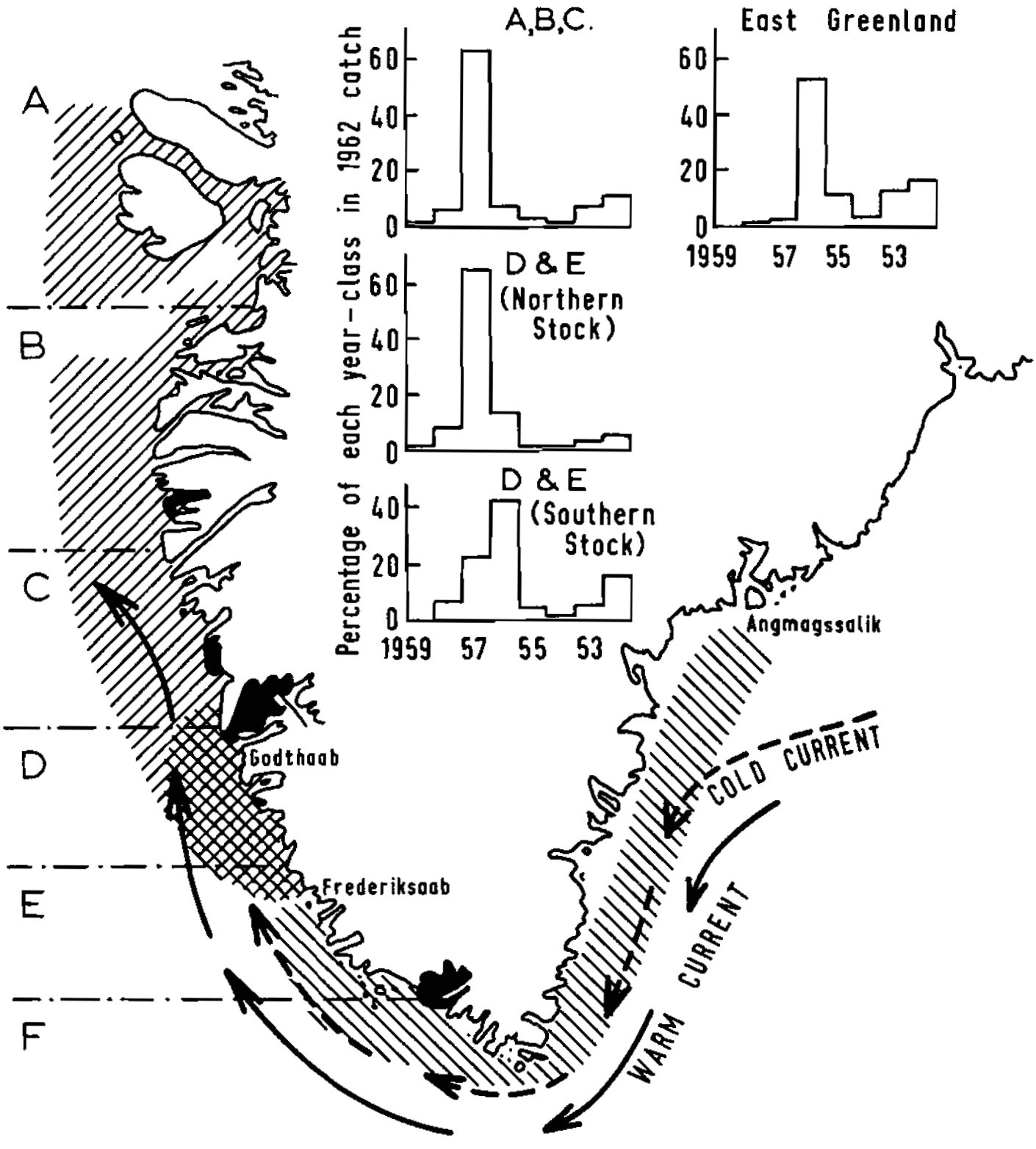

Figure 1. The distribution and age structure of cod stocks, and the oceanic currents at West Greenland.

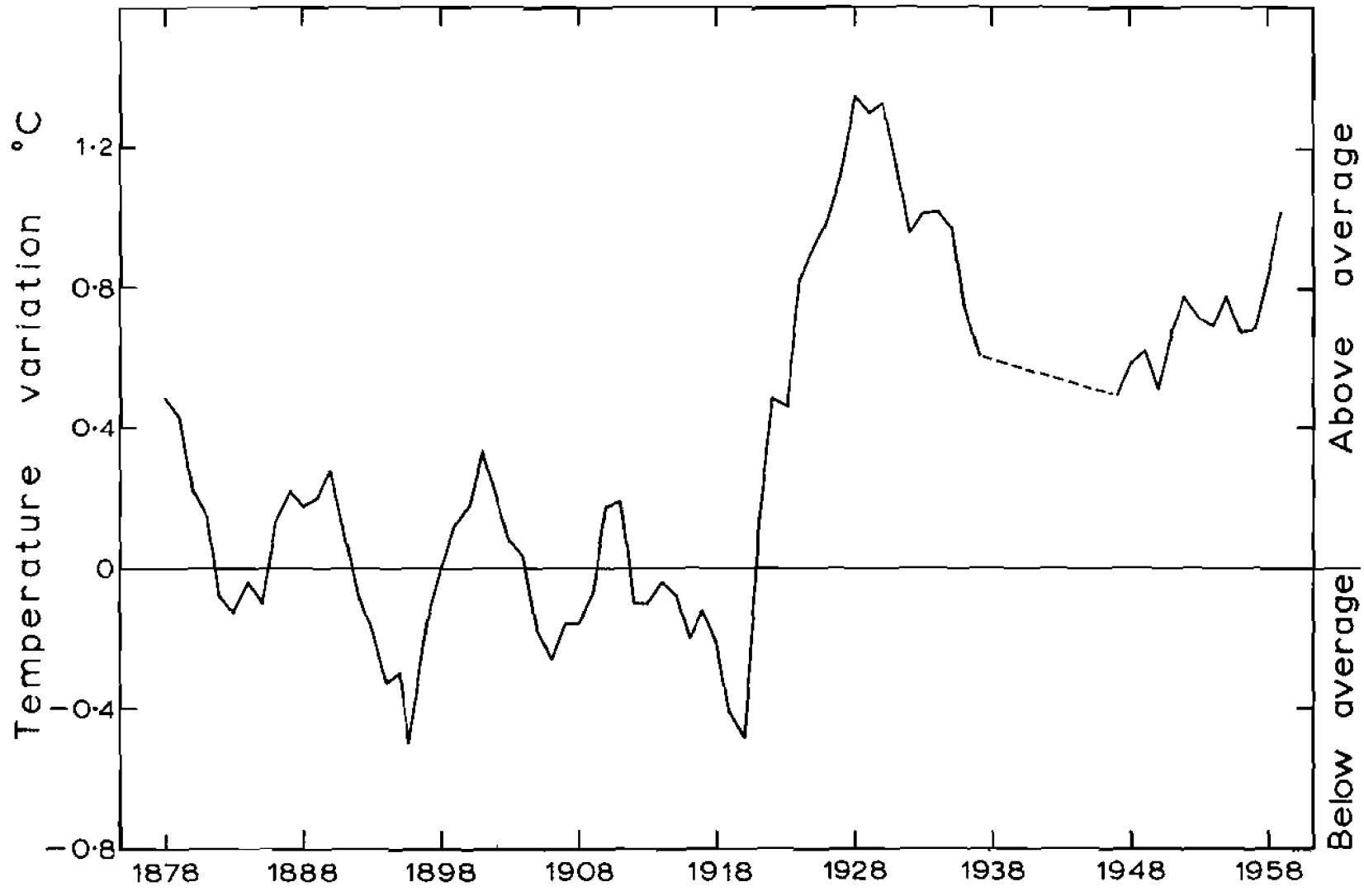

Figure 2. Variations in surface water temperature at West Greenland, 1878-1958. (Taken from the results of Danish scientists.)

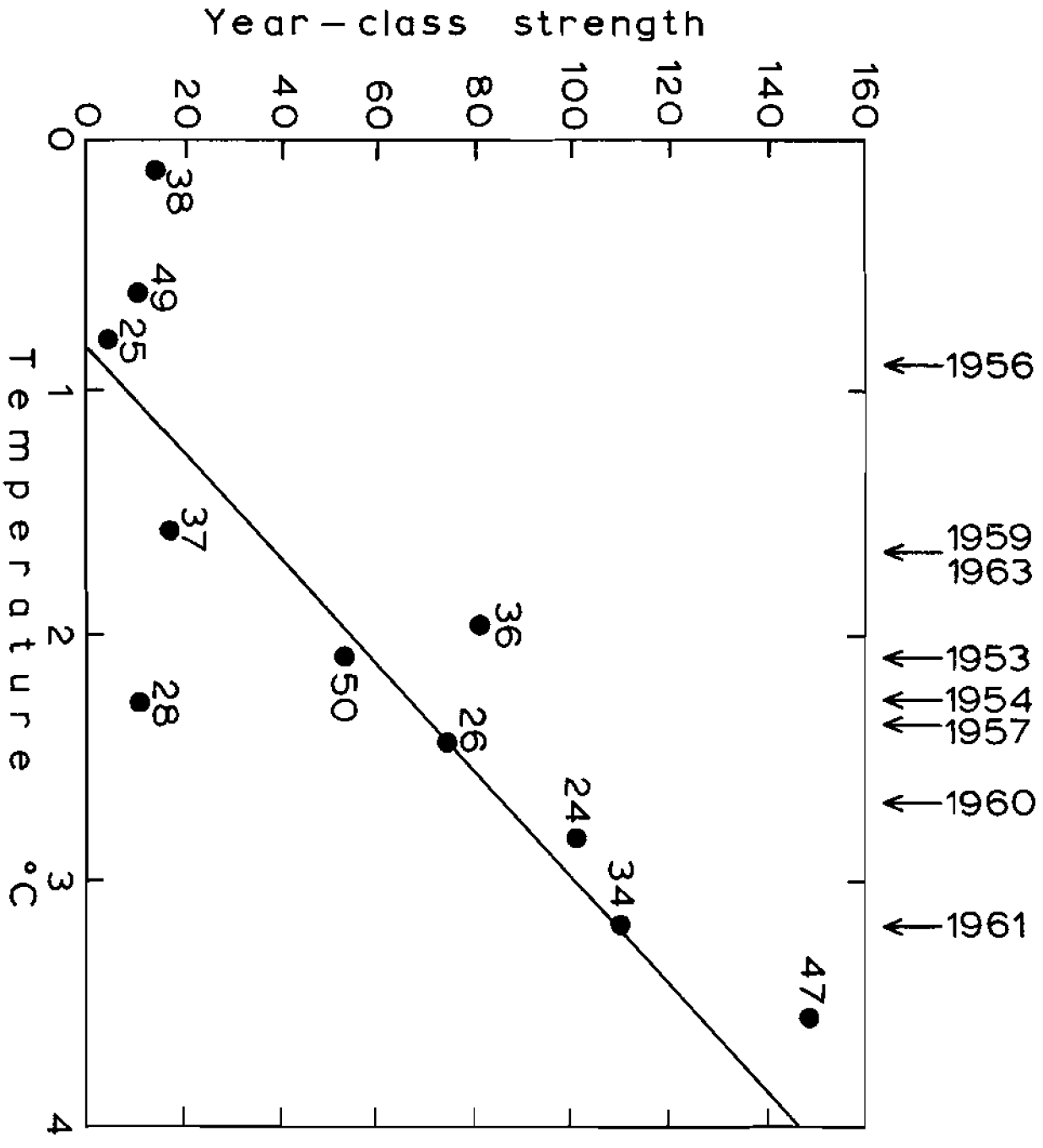

Figure 3. Variations of year-class strength of cod at West Greenland, as measured by the mean temperature of water over Fyllas Bank in June. (Taken from the results of Danish scientists.)

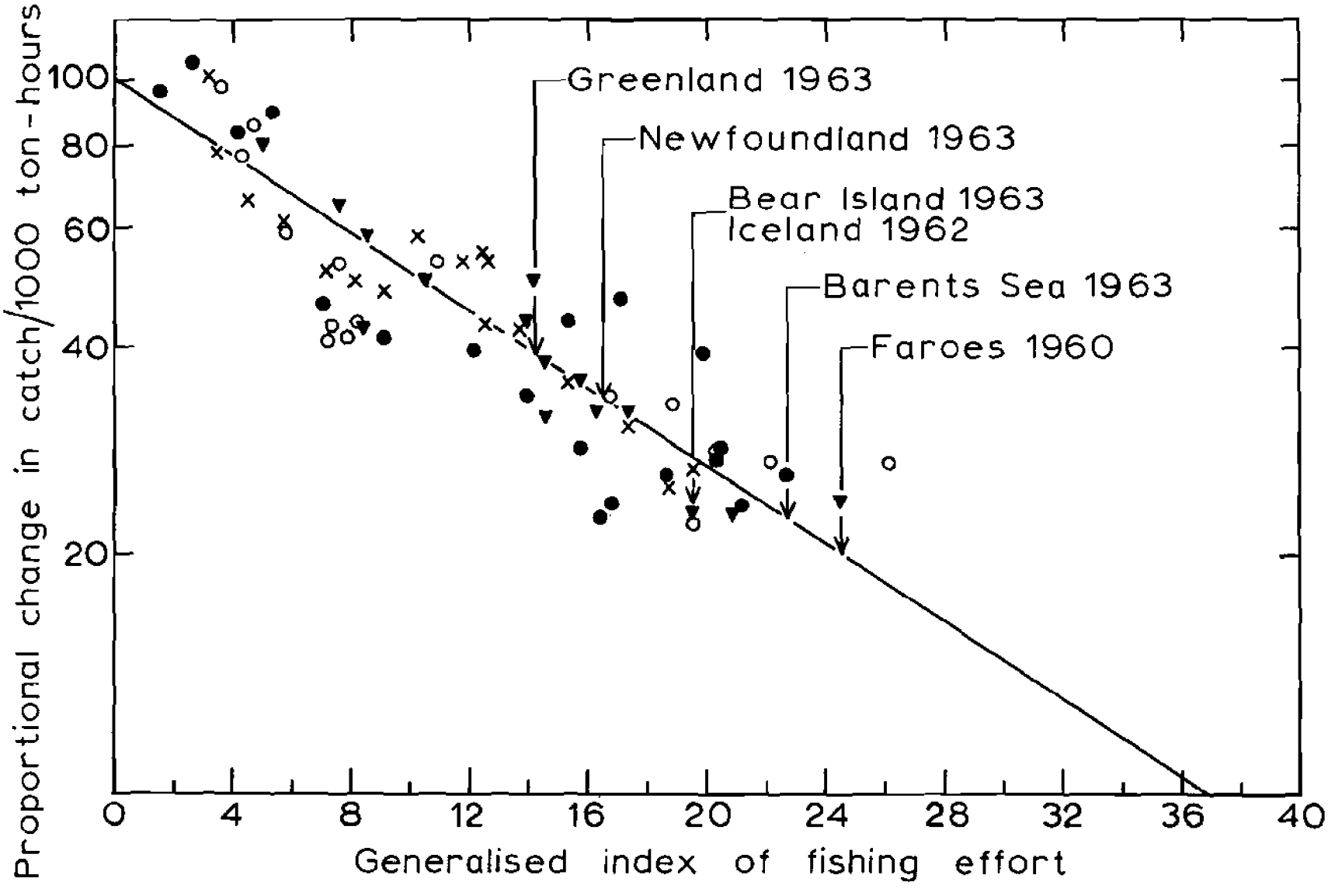

Figure 4. The generalised relationship between the abundance of fish and the amount of fishing in the United Kingdom distant-water cod fisheries.

Key: ● Barents Sea × Iceland ○ Bear Island ▼ Faroes

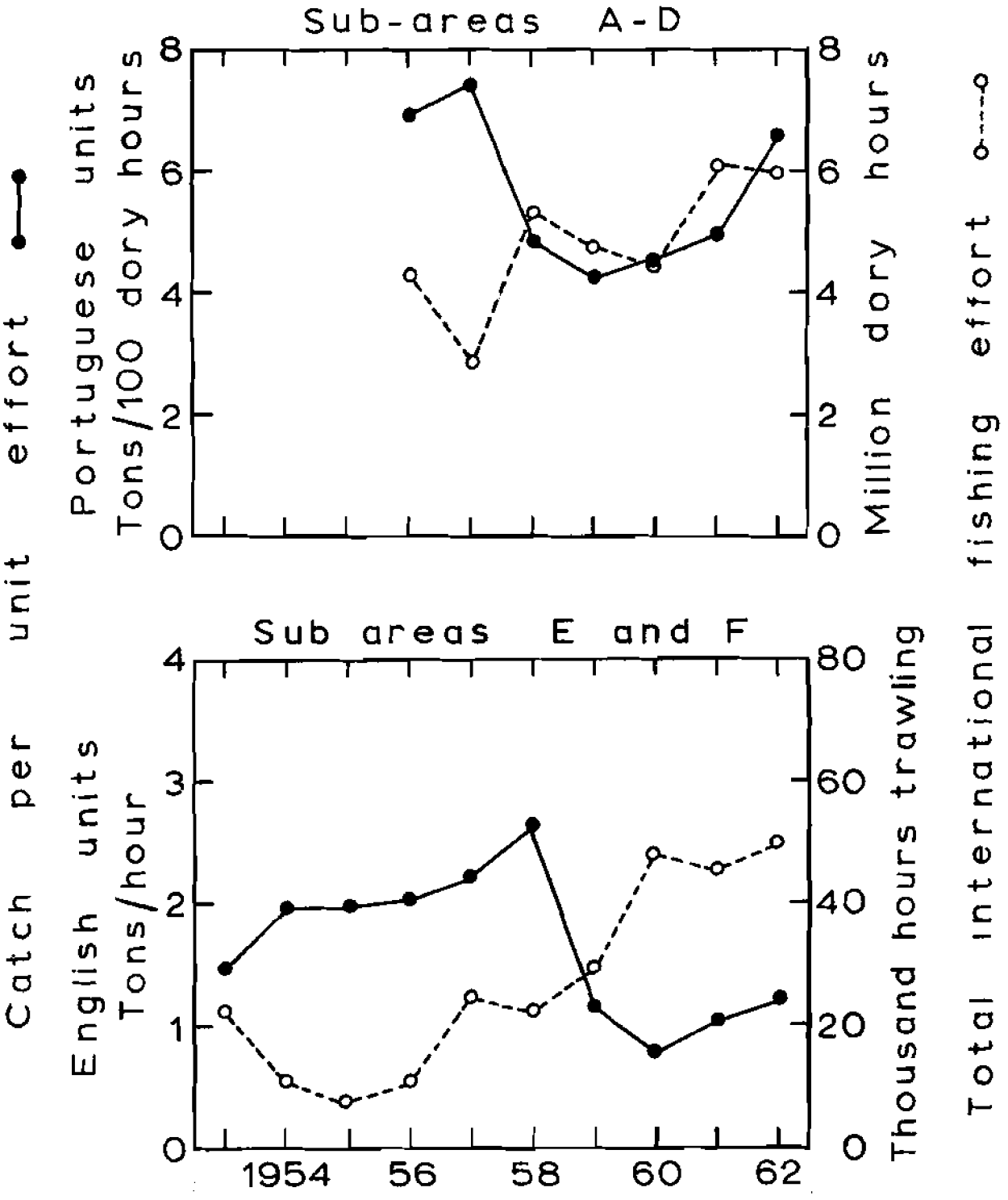

Figure 5. Recent trends in the catch rate and amount of fishing on the two main stocks of cod at Greenland.

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